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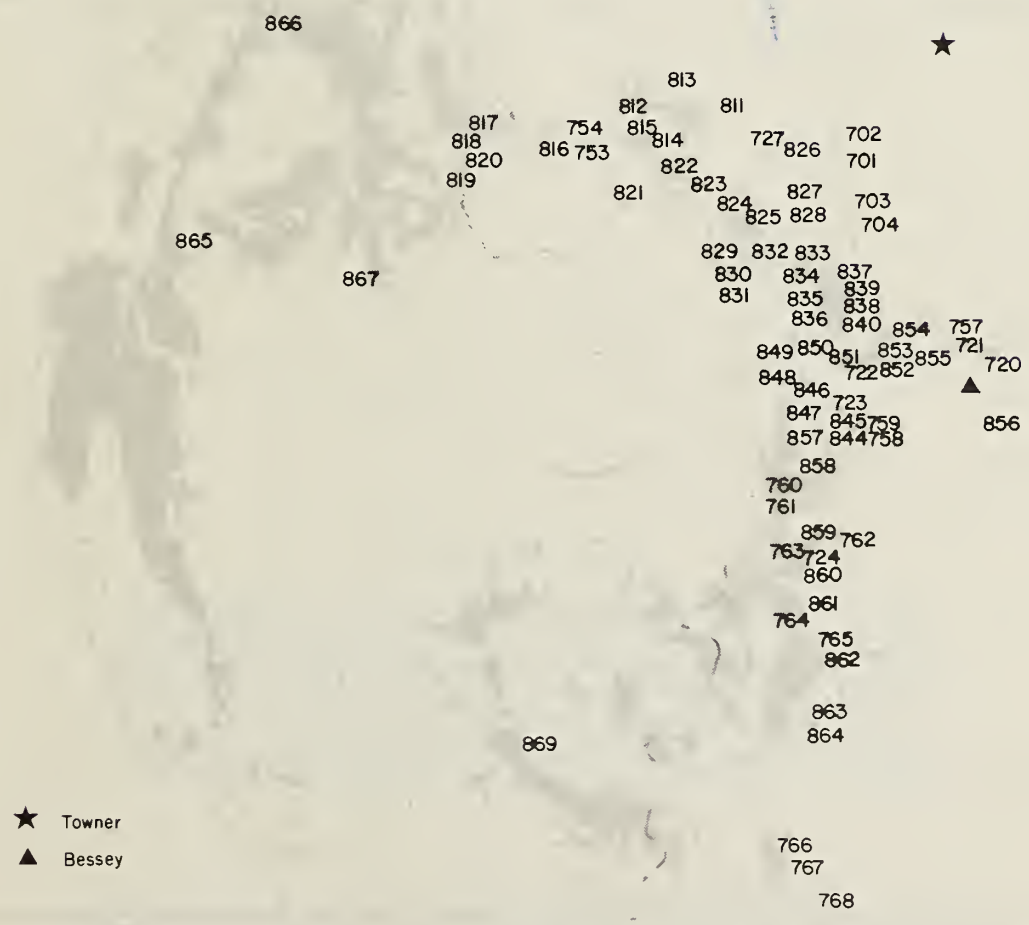
Ten-Year Performance of Ponderosa Pine Provenances in the Great Plains of North America

Ralph A. Read



Abstract

A cluster and discriminant analysis based on nine of the best plantations, partitioned the seed provenance populations into six geographic clusters according to their consistency of performance in the plantations.

The Northcentral Nebraska cluster of three provenances performed consistently well above the average in all plantations. These easternmost stands of ponderosa pine along the Niobrara River escarpment in Nebraska from about 101° longitude and eastward, and those in the drainage of the South Fork of the White River near Rosebud, S. Dak., are recommended for tree planting in all Great Plains states.

Acknowledgements

Much of the cooperation in establishment of the ponderosa pine provenance plantations reported in this paper was accomplished through the Regional Forest Tree Improvement Committee (NC-99) of the North Central State Agricultural Experiment Stations. In addition to all principal cooperators (appendix), the author thanks all the technicians and graduate assistants who participated in the layout, planting, maintenance, and measurement of the various plantations.

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Ralph A. Read, Principal Silviculturist
Rocky Mountain Forest and Range Experiment Station[1]

[1]*The author, now retired, was with the Station's Research Work Unit in Lincoln, in cooperation with the University of Nebraska. Station's headquarters is at Fort Collins, in cooperation with Colorado State University.*

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Management Implications

Based on the 10-year results of this study, use of ponderosa pine seed provenances from the Northcentral Nebraska cluster (table 4) is recommended for all states in the Great Plains area. More specifically, these include the easternmost ponderosa pine stands along the Niobrara River escarpment from south of Nenzel, Nebr. eastward, and in the drainage of the South Fork of the White River, near Rosebud, S. Dak.

In addition to those areas, practitioners should carefully study the data in table 3, to make use of other seed provenances which show up as plus or double plus in plantations closest to their planting sites. For example, provenances 822 and 825 in central Montana can be recommended, because they performed well above plantation means in more than 80% of the plantations (table 4). Seed provenances which show predominantly minus symbols in table 3 should be scrupulously avoided.

Several of the best performing seed provenances require additional comment, especially 824 and 825 in Montana, which are within an area of intensive coal strip mining. If these stands are to be kept available for seed collections, immediate action is needed. The three provenances in the Northcentral Nebraska cluster are in less danger, because they occupy private ranch lands or the Rosebud Sioux reservation lands.

These results are based on the two traits of survival and height growth. In time, other traits are very likely to be of equal importance. Traits such as needle and branching (Read and Sprackling 1981), flowering (Read and Sprackling 1983), stem form (La Farge 1975), insect susceptibility (Dix and Jennings 1982), disease susceptibility (Peterson and Read 1977), and drought resistance, all are important in the evaluation of seed provenances for use in Great Plains tree plantings. These traits should be included in future studies to provide a more comprehensive basis for population delineation by cluster analysis.

Although growth rates are probably at a maximum between 5 and 20 years, they are likely to decline after that period. Namkoong and Conkle (1976) found this to be the case in a 29-year study of elevational transect seed provenances in California. They cautioned that selection of genotypes should be delayed until the declining growth phase can be adequately observed. Therefore, it is possible that the seed provenances recommended here, which are based upon 10-year height growth, may change after 20 years of evaluation.

Introduction

The ponderosa pine complex (*Pinus ponderosa* Dougl. ex Laws.) in western North America (fig. 1) extends from north latitude 23° near San Luis Potosi, Mexico to 52° in southern British Columbia, Canada; and from west longitude 99° in north-central Nebraska to 124° along the California coast (Critchfield and Little 1966). Thus, these forests grow under an extremely wide range of soil types and climatic conditions.

Three varieties are presently recognized within this complex (Little 1979). Typical variety *ponderosa* extends from British Columbia, west of the Continental Divide, to the Snake River Plain in southern Idaho; south along the Cascade and Coast Ranges in Washington and Oregon; and in the Coast and Sierra Nevada Ranges of California to near San Diego.

The Rocky Mountain variety, *scopulorum* Engelm., known also as interior ponderosa pine, extends from 48° in northcentral Montana, east of the Continental Divide, southeasterly into North Dakota, South Dakota, Wyoming, and Nebraska. South of Wyoming this variety occurs on both sides of the Divide in Colorado, and westward into Utah and Nevada. The name *scopulorum* is sometimes extended south of the region to which it initially applied, i.e., to stands in New Mexico, Arizona, and west Texas. However, the ponderosa pine in these southern stands is distinctly different from those of the northern range *scopulorum*, especially in needle and monoterpene characteristics (Read 1980, Smith 1977).

The variety *arizonica* (Engelm.) Shaw—*Pinus arizonica* according to some authorities—extends from southwest New Mexico and southeastern Arizona southward along the Sierra Madre Occidental to near Durango, and along the Sierra Madre Oriental to near San Luis Potosi, Mexico.

Although older studies of ponderosa pine—near Pikes Peak in Colorado (1910), and Priest River, Idaho (1911)—are considered to be the earliest examples of provenance tests of forest trees in North America (Wang 1979), subsequent genetic research in ponderosa pine has concentrated mainly on the West Coast variety *ponderosa*.

Studies of genetic variation throughout the entire natural range of ponderosa pine have used various analyses to delineate varieties (Korstian 1924), geographic races (Weidman 1939), ecotypes (Wells 1964a, 1964b), regions and zones (Smith 1977), or geographic clusters (Read 1980). These studies and a study by Squillace and Silen (1962), have indicated the existence of smaller geographic groups within the populations of each variety. Because most of these

Figure 1.—Natural distribution of ponderosa pine (after Critchfield and Little 1966); location of collections in this study; and location of the two nurseries where planting stock was grown.

studies have shown that there are distinct differences in characteristics such as growth rate, seed germination rate, time of growth initiation, needle morphology, and monoterpenes, among subpopulations, it is important that such variations be recognized not only in forest management practice, but especially in seed collection practices.

The present study provides new knowledge of genetic variation in the eastern range of variety *scopulorum*, and south into New Mexico and Arizona.

The Present Study

This study was begun 20 years ago to determine the best seed provenances of ponderosa pine for use in protection plantings in the Great Plains of the United States. The first phase of the study involved assessment of seedling growth and traits in the nursery (Read 1980).

This paper continues that study by assessing the performance of the seed provenances after 10 years growth, in 17 widely dispersed field plantations. Performance data are used to revise the previous delineation of geographic clusters within the populations, and thus provide an improved basis for selecting seed provenances.

The 10-year height growth of each seed provenance, in each of 9 field plantations is used as a basis to delineate geographic clusters of seed provenances whose performance relative to other seed provenances was similar in all plantations. No other traits were measured; therefore, the results presented are based exclusively on survival and growth. Results do not address the specific interactions of survival and growth with disease or insect infestation, which might be expected to differ by seed provenance; instead, they include those effects as part of survival and growth response.

The geographic clustering resulting from the present analysis is not identical to the geographic clustering derived from the nursery seedling analysis; however, there are similarities. The seedling analysis was made on performance in a relatively uniform nursery environment, whereas field performance encompassed sites that were widely different in soil and climatic conditions. Therefore, the pertinent aspects to look for are the similarities in the general trends revealed by the two clustering analyses.

The study was begun in the early 1960's in a cooperative effort by the North Central and the Rocky Mountain Stations of the USDA Forest Service. The plan of study was prepared by scientists of the Northern Institute of Forest Genetics.[2] The objectives were:

1. to acquire knowledge of the extent and distribution of genetic variation in natural stands of the eastern range of ponderosa pine;
2. to find the best adapted seed provenances for planting in different parts of the Great Plains; and
3. to provide a broad range of genetic materials at convenient sites for the selection and breeding of improved trees, and for long-term studies of drought, disease, and insect resistance.

The nursery seedling evaluation phase of the study and its part in meeting the first objective has been reported by Read (1980). A complete description of the materials used in this study is contained in that publication. Briefly, seeds were collected from 1962 through 1964, from 10 to 15 trees in each population, sampled at each of 79 locations (fig. 1). Seven locations were in the var. *ponderosa* region, generally west of the Continental Divide, and 72 locations were in the var. *scopulorum* region of the eastern range. Seedlings for the nursery study and planting stock for the field study were grown at the Forest Service Bessey Nursery in Nebraska, and at North Dakota's Towner Nursery from 1965 through 1968 (fig. 1).

Field plantations were established from 1968 through 1970. Preliminary data and height growth performance have been published as follows·

- Browsing preferences by jackrabbits in Nebraska (Read 1971).
- Variation in resin canal numbers in Kansas (Deneke and Funsch 1972).
- 5-year height in Minnesota (Tauer, Mohn, and Cromell 1974).
- 5-year height in Black Hills, South Dakota (Van Deusen 1974).
- 6-year height in Kansas (Deneke and Read 1975).
- 4- and 6-year height in Pennsylvania (Davidson 1977).
- Western gall rust in Nebraska (Peterson and Read 1977).
- 9-year height in Oklahoma (Tauer and Gardner 1978).
- 10-year height in South Dakota (Baer and Collins 1979).
- 10-year height in North Dakota (Van Deusen 1980).
- Hail damage variation in Nebraska (Read and Sprackling 1981).
- 10-year height in Minnesota (Radsliff et al. 1981).
- Western pine tipmoth in Nebraska (Dix and Jennings 1982).
- Flowering at 13 years in Nebraska (Read and Sprackling 1983).

[2] *Nienstaedt, Hans, and David H. Dawson. 1964. Study workplan for ponderosa pine for the Great Plains region (a study of the adaptability of provenances from the eastern portions of its native range). Lake States Forest Experiment Station (now North Central), USDA Forest Service, 94 p. (On file Rocky Mountain Station Laboratory, Lincoln, Nebr.).*

Materials and Methods

Field plantations of the seed provenance progenies were established at various locations (fig. 2), mostly in the Great Plains, from 1968 through 1970.[3] Twenty-eight plantations were initially established. Ten of them were omitted because they had very low survival or no data available. A 4-tree-plot plantation at Hastings, Nebr. was omitted, because a 25-tree-plot plantation at that location provided adequate representation.

The basic design for field testing was to be randomized blocks with 4-tree plots and 15 replications. That design was followed in seven plantations. However, for various reasons, some cooperators used 6- or 10-tree plots, while others divided their materials, in order to plant fewer replicates at several locations. Three plantations contained 50 or fewer of the 79 seed provenances; the Plattsmouth, Nebr. and Norman, Okla. plantations were designed that way. The Philipsburg, Pa. plantation contained only 49 seed provenances because of planting stock shortage.

Data on location and layout design for the 17 plantations in this paper are shown in table 1. Methods of site preparation and maintenance after planting were left to the judgment of each cooperator. In most plantations, land was prepared by plowing, disking, rotovating, or harrowing. In a few plantations on light sandy soils, the sites were not disturbed, except by herbicide applied to control grass, weeds, or brush. Maintenance ranged from harrowing, over-the-row cultivation, and herbicide application to mowing. Only one plantation received no maintenance. Control of gophers, rabbits, or porcupines was necessary in several plantations.

Spacing of trees within each layout was left to the discretion of each cooperator. It ranged from 6 x 6 feet in the Michigan and Pennsylvania plantations to 6 x 8, 6 x 12, 8 x 8, 8 x 12, and 8 x 13 feet to 12 x 12 feet in Oklahoma.

Planting stock distribution from the two nurseries was as follows: Saskatchewan, North Dakota, Minnesota, South Dakota, and Michigan received stock grown at Towner, N. Dak.; Alberta, Nebraska, Kansas, Oklahoma, Missouri and Pennsylvania received stock grown at Bessey Nursery, Nebraska.

In the analysis of data, the primary objective was to identify superior seed provenances across the range of plantation locations. As the first step, the 10-year height data of each plantation were subjected to standard analysis of variance and unequal sample size multiple range tests. These analyses indicated the presence of significant variation among seed provenances for each plantation. However, the replication of each seed provenance was sufficient to statistically detect only differences between extremes (i.e., the tallest from the shortest provenances). Therefore, because the results were not particularly informative, they are not reported.

ISODATA cluster analysis (Ball and Hall 1965, 1966) was then used to group seed provenances based on the

[3] *Read, Ralph A., and Paul E. Slabaugh. Establishment Report for Ponderosa Pine Provenances for the Great Plains. Timber Management Research Studies: 1501.13, Lincoln, Nebr.; 1502.4, Bottineau, N. Dak. 1971, 101 p. (mimeographed).*

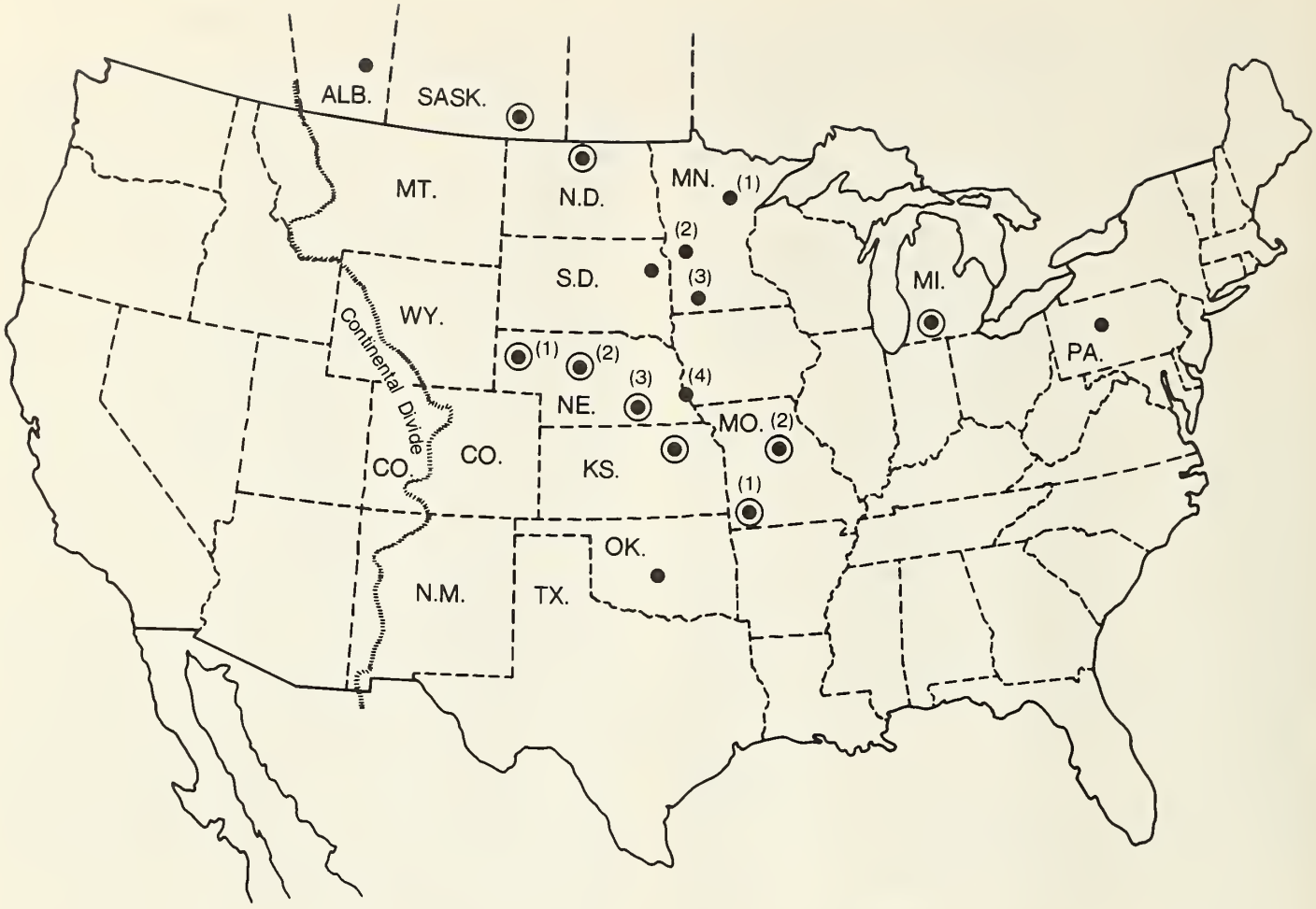

Figure 2.—Location of the seventeen field plantations. Circled locations are those used in ISODATA analysis. Numbers in ( ) are used in Tables 1 and 2.

Table 1.—Location and establishment data for the seventeen plantations, grouped by Northern, Central, and Southern and Eastern locations

No. of State or Province	Plantation location	°Lat.	°Long.	Elevation (ft)	Elevation (m)	Seed provenances	Trees per plot	Repli-cations	Trees per provenance
ALB	Drumheller	51.3	112.6	2,660	811	63	10	3	30
SASK	Indianhead	50.4	103.6	1,800	549	70	4	15	60
ND	Towner	48.4	100.4	1,500	457	79	4	15	60
MN (1)	Grand Rapids	47.2	93.5	1,300	396	70	4	3	12
MN (2)	Morris	45.6	95.9	1,100	335	72	4	6	24
MN (3)	Lamberton	44.2	95.2	1,000	305	72	4	9	36
SD	Watertown	44.9	97.1	1,740	530	73	4	8	32
NE (1)	Alliance	42.1	102.9	4,000	1219	79	4	15	60
NE (2)	Halsey	41.9	100.4	2,900	884	79	4	15	60
NE (3)	Hastings	40.6	98.3	1,900	579	79	25	4	100
NE (4)	Plattsmouth	41.0	95.9	1,100	335	50	10	6	60
KS	Milford	39.0	96.9	1,000	305	77	4	15	60
OK	Norman	35.1	97.5	1,100	335	40	4	15	60
MO (1)	Mt. Vernon	37.1	93.9	1,200	366	78	4	10	40
MO (2)	Columbia	38.9	92.2	700	213	78	4	10	40
MI	Kellog	42.4	85.4	800	244	75	6	5	30
PA	Philipsburg	41.0	78.2	1,600	488	49	10	6	60

similarity in relative height growth across the range of plantation locations.

Because performance in each plantation was independent of all other plantations, the average height growth of each seed provenance in the different plantations was used as an independent trait. Use of the cluster analysis makes it possible to ascertain how consistently similar, or not, the seed provenances or clusters behave in all plantations.

To perform the cluster analysis using all provenances and all plantations, it would have been necessary to estimate 160 missing cells in the matrix of 79 seed provenances and 17 plantations (about 12% of total). Sixty-eight missing cells were in two of the plantations at Plattsmouth, Nebr. and Norman, Okla., which were designed that way. Shortage of planting stock of Oregon, Washington, Idaho, and four Bitterroot, Montana seed provenances, which were not planted in approximately half the plantations, was responsible for the remaining missing values.

Therefore, to include the maximum number of provenances (78) with a minimum insertion of estimated values, nine plantations were chosen (fig. 2) for analysis: Saskatchewan, North Dakota, three Nebraska locations, Kansas, two Missouri locations, and Michigan. Provenance 753 was omitted in analysis because it was planted in only five plantations; however, it is included in the data tables along with other provenances in the large cluster which covers most of central and eastern Montana. Excluding that provenance, only 12 missing plot values had to be estimated by a randomized block technique (John 1971).

Discriminant analysis was used to assess the degree of separation among the clusters of seed provenances. Individual provenances, possibly misclassified by the cluster analysis, were also identified and were placed in the indicated cluster.

Average tree heights for each seed provenance were converted to percentages of each plantation's mean. This technique is commonly used to compare relative heights of seed provenances in widely dispersed plantations, where different environments have produced large differences in mean growth of plantations. The allocation of these percentages into broad performance classes then facilities comparison among plantations to show consistency, or lack of it, in how seed provenances perform across all plantations.

Results and Discussion

The geographic clusters delineated in the cluster analysis of 9 plantations and 78 seed provenances were clearly distinct, with few exceptions. Discriminant analysis, which applied unequal weighting to the plantations according to ability to distinguish among the clusters (cluster analysis applies equal weighting), identified only two provenances possibly misclassified. Provenance 727, first placed in the Foothills-Black Hills cluster, was considered more likely to belong in the Northern High Plains cluster. Provenance 867, first placed in the Southern cluster, was judged to be part of the Northwest cluster. Apart from these two misfits, the separation among clusters was good with posterior probabilities of generally 0.8 or larger that cluster members were properly classified. Results are summarized in figure 3 and table 2.

The seven provenances west of the Continental Divide in the Northwest formed a distinct cluster. This agrees with results of the cluster analysis of seedling traits which described this group as var. *ponderosa* (Read 1980). All provenances in this cluster were generally poor performers in the Great Plains plantations, showing low survivals and slow growth. The only exceptions were in the Missouri and Michigan plantations, where several provenances, including Idaho and Washington, appeared sufficiently adapted to perform well.

The five Southern seed provenances formed another distinct cluster in central and southern New Mexico and Arizona. In the seedling analysis (Read 1980), this cluster included three provenances in southern Colorado and northern New Mexico (765, 862, 863). The failure and poor performance of these five Southern provenances in all northern plantations, where they were not adapted, accounts for the difference in clustering in this southern range. Southern provenances survived reasonably well in Nebraska and southward plantations, but they grew well only in the Plattsmouth, Nebr., Oklahoma, and Missouri plantations.

The Central Rocky Mountain cluster, though smaller than that obtained in the seedling analysis (Read 1980), is nevertheless indicative of a group of seed provenances of low growth potential for use in the Great Plains. Practically all 10 provenances in this cluster, although showing reasonably good survival, were below average performance in all plantations.

In contrast to the three previously described clusters, the Northern High Plains cluster of 25 seed provenances in central and eastern Montana, and extending southeastward to the east of the Black Hills into northwestern Nebraska, contains a number of high performance, and only a few low performance seed provenances. In all 17 plantations, the average survival and performance of the 25 seed provenances in this cluster was consistently above the plantation means.

The cluster of three provenances in Northcentral Nebraska and adjacent southcentral South Dakota was distinct. These provenances survived and grew in height consistently better than any other cluster in practically all plantations. Except for one isolated Nebraska population (856), these seed provenances represent the extreme eastern range of the species.

The cluster of 29 provenances designated as Foothills-Black Hills appeared to be intermediate in growth, between the Northern High Plains and the Central Rocky Mountain clusters, at least in the central, southern, and eastern plantations. Seed provenance locations in this cluster ranged from northcentral Montana to northern New Mexico; and with the exception of three provenances in northern Montana, one in North Dakota, and one in central Nebraska, all formed a fairly cohesive cluster. None of the seed provenances were consistently high performers; but some northern Montana prove-

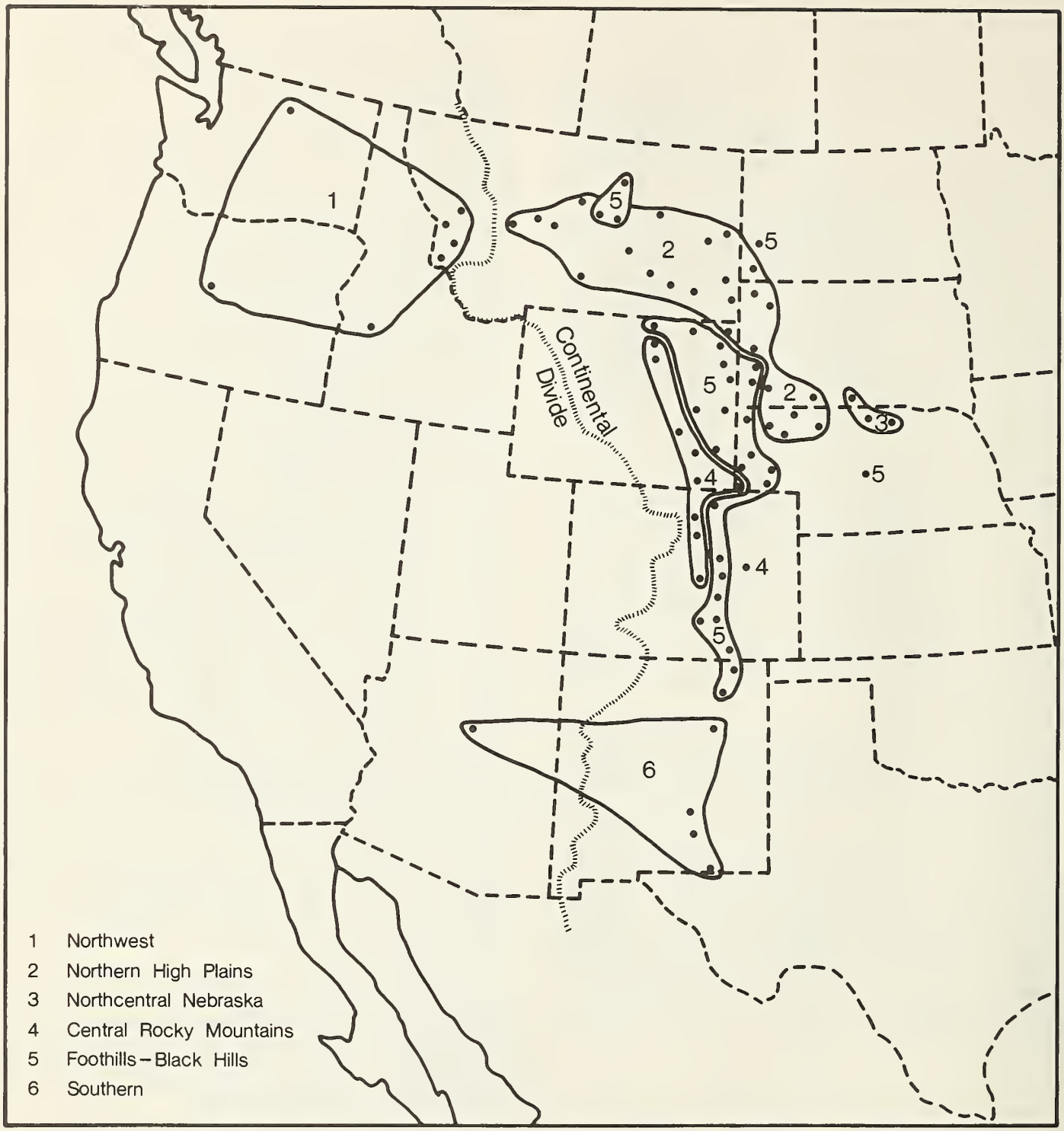

Figure 3.—Delineation of population clusters as derived from the cluster-discriminate analysis.

nances were excellent in Alberta, and some Black Hills provenances were top performers in the western Nebraska plantation.

Average percent survival data for all 78 seed provenances and plantations (except Michigan) showed a similar, but not identical, clustering as the growth data. The data reveal that provenances in the Northcentral Nebraska and the Northern High Plains clusters generally survived the best. The Central Rocky Mountains and the Foothills-Black Hills clusters showed slightly poorer survival. Provenances in the Northwest and the Southern clusters generally exhibited poor survival. Some variation in this general trend was present for particular plantations.

Table 2.—Mean survival, height, and percent of plantation $\bar{x}$ of the six clusters by plantations[1]

Cluster	No. of Provenances		Northern Plantations ALB	SASK	ND	MN (1)	MN (2)	MN (3)	SD	Central Plantations NE (1)	NE (2)	NE (3)	NE (4)	KS	Southern and Eastern Plantations OK	MO (1)	MO (2)	MI	PA
Northwest	7	% surv.	65	9	12	54	42	26	73	31	26	64	96	54	66	91	92	-	np
		Mean Ht.	2.5	3.8	1.6	5.2	5.6	3.9	5.6	4.4	3.3	7.8	13.0	3.3	7.0	8.2	10.0	13.1	
		% PL. $\bar{X}$	66	68	70	87	83	59	76	66	80	91	101	79	98	95	107	111	
Northern High Plains	25	% surv.	75	60	61	76	69	58	94	80	48	99	99	90	88	99	93	-	65
		Mean Ht.	4.2	6.0	2.4	6.4	7.4	7.2	8.3	7.0	4.6	9.2	13.7	4.6	7.3	9.0	10.0	12.4	5.7
		% PL. $\bar{X}$	110	108	105	107	110	109	112	104	112	107	107	110	102	105	107	105	105
North-Central Nebraska	3	% surv.	77	68	72	75	81	65	95	79	42	99	100	88	91	99	96	-	64
		Mean Ht.	4.4	7.6	3.3	6.4	8.4	8.1	9.6	7.7	5.5	11.3	14.9	7.1	10.5	10.7	10.7	13.8	7.4
		% PL. $\bar{X}$	115	136	145	107	125	123	130	115	133	132	116	170	147	124	114	117	137
Central Rocky Mountains	10	% surv.	68	34	47	71	68	49	82	87	41	99	98	85	74	96	85	-	69
		Mean Ht.	3.6	4.2	2.0	5.2	5.5	5.7	6.0	6.2	3.3	7.2	11.0	3.4	5.4	6.9	7.4	10.0	4.7
		% PL. $\bar{X}$	94	75	88	87	82	86	81	92	80	84	86	81	76	80	79	85	87
Foothills-Black Hills	29	% surv.	63	42	44	61	62	49	84	85	38	98	98	87	77	98	91	-	56
		Mean Ht.	3.6	5.0	2.0	5.8	6.4	6.3	6.9	6.8	3.9	8.4	12.5	4.0	6.7	8.5	9.1	11.6	5.3
		% PL. $\bar{X}$	94	90	88	97	95	96	93	101	95	98	97	96	94	99	97	98	98
Southern	5	% surv.	0	0	0	0	0	14	17	64	6	77	91	64	75	86	69	-	np
		Mean Ht.	0	0	0	0	0	4.7	2.2	6.3	1.1	7.8	13.1	3.6	7.7	10.4	10.2	11.9	
		% PL. $\bar{X}$	0	0	0	0	0	71	30	94	27	91	102	86	108	121	109	101	
Provenances	79		63	70	79	70	72	72	73	79	79	79	50	77	40	78	78	75	49
Plantation:																			
Mean survival (%)			66	44	45	66	61	50	84	77	37	94	98	83	80	96	89	-	61
Mean height (feet)			3.8	5.6	2.3	6.0	6.7	6.6	7.4	6.7	4.1	8.6	12.8	4.2	7.1	8.6	9.4	11.8	5.4
Cluster basis				*	*					*	*	*		*		*	*	*	

[1]*Explanotion: np = none planted; 0 = planted, zero survived; * = plantations used in ISODATA cluster analysis (see circled locotions in Fig. 2).*

The consistent performance of seed provenances in the Northcentral Nebraska and the Northern High Plains clusters is very remarkable, in that this response extends across all or nearly all plantations. Consider the range of climatic variables from Oklahoma to Alberta (over 16 degrees latitude), and from Alberta to Michigan and Pennsylvania (over 34° longitude). Mean annual temperature ranges from 60° F in Oklahoma to approximately 30° F in Alberta, and mean annual precipitation from 32 inches to a little more than 10 inches. The growing season averages 224 days in Oklahoma but less than 100 days in Alberta.

Under such a large range of environmental conditions, the evidence is strong that the northcentral Nebraska and southcentral South Dakota provenances, and some in central Montana, contain genes endowing them with a much broader range of site tolerance for the Great Plains, than for example the seed provenances in the Central Rocky Mountain cluster.

Mean heights of each seed provenance by cluster and plantation are shown in table 3A (Northern), table 3B (Central), and table 3C (Southern and Eastern) plantations. Included in these tables are symbols which denote a subjective characterization of height growth in each plantation. These are intended only to show a comparison of similarities and differences across plantations and do not imply statistical significance. The mean heights of each provenance in a plantation, relative to the plantation mean, are divided into five broad percentage groups, as follows:

+ +	heights greater than 130% of plantation mean
+	heights ranging from 111% to 130%
no symbol	heights ranging from 90% to 110% about the mean
–	heights ranging from 70% to 89%
– –	heights less than 70% of plantation mean

In the seven northern plantations (table 3A), the Southern cluster provenances either failed or grew very slowly. Provenances of the Central Rocky Mountains, most of the provenances in the Foothills-Black Hills cluster, and all Northwest provenances showed poor performance. The best provenances in these northern plantations were from the Northern High Plains and Northcentral Nebraska clusters. Central and eastern Montana provenances 816, 812, 821, 822, 811, 824, 825, 727, and 826 all showed better than 110% performance in more than half of these plantations. One provenance 837 from the eastern side of Black Hills performed well in four of the seven plantations. Northcentral Nebraska provenances 720 and 721, and southcentral South Dakota 757 performed exceptionally well in nearly all plantations.

In five central Great Plains plantations (table 3B), growth performance was similar but showed a slightly different pattern than in the northern plantations. The southern provenances from New Mexico, Arizona, and southern Colorado survived in most plantings, in contrast to performance in northern plantations; but growth rate was only average or below. All Central Rocky Mountain and Northwest provenances were poor performers. As in the northern plantations, certain provenances from central and eastern Montana were consistently taller than plantation means. In addition, some Black Hills provenances and several from western Nebraska (833 through 855) showed up as good performers. The Northcentral Nebraska provenances 720 and 721, and South Dakota 757 performed exceptionally well, as in the northern plantations.

In the three southern and two eastern plantations (table 3C), the three Northcentral Nebraska provenances again show up as the fast-growers. Central and eastern Montana provenances also grew well in most plantations. The only plantations in which Southern provenances appear to be well adapted were Oklahoma and Missouri. However, the three southernmost provenances of the Foothills-Black Hills Cluster, 765, 862, and 863, appeared to be well-adapted in Missouri and in Pennsylvania. The Washington and Idaho provenances appeared as fast-growers in central Missouri and in Michigan. All Central Rocky Mountain provenances performed poorly in all five of these plantations.

Based on the 10-year results of this study, use of ponderosa pine seed provenances from the Northcentral Nebraska cluster (table 4) is recommended for all states in the Great Plains area. More specifically, these include the easternmost ponderosa pine stands along the Niobrara River escarpment from south of Nenzel, Nebr. eastward, and in the drainage of the South Fork of the White River, near Rosebud, S. Dak.

In addition to those areas, practitioners should carefully study the data in table 3, to make use of other seed provenances which show up as plus or double plus in plantations closest to their planting sites. For example, provenances 822 and 825 in central Montana can be recommended, because they performed well above plantation means in more than 80% of the plantations (table 4). Seed provenances which show predominantly minus symbols in table 3 should be scrupulously avoided.

Table 3A.—Average tree heights (in feet) for each seed provenance in Northern plantations, and symbols to show percentage-of-plantation mean classes[1]

Seed Provenance Location & No.		Drumheller ALB	Indianhead SASK	Towner ND	Grand Rapids MN	Morris MN	Lamberton MN	Watertown SD
Northwest								
OR	865	np	3.4 --	1.3 --	4.4 –	np	np	5.6 –
WA	866	np	4.5 –	1.4 --	5.9	6.3	5.0 –	7.2
ID	867	np	0 --	0 --	np	4.5 --	3.3 --	3.8 --
MT	817	np	np	2.5	np	np	np	np
MT	818	np	np	1.8 –	np	np	np	np
MT	819	2.5 --	np	1.6 –	np	np	np	np
MT	820	np	np	1.7 –	np	np	np	np
Northern High Plains								
MT	816	4.3 +	6.1	2.8 +	6.6 +	7.9 +	7.1	8.7 +
MT	754	3.4 –	5.6	2.7 +	5.7	5.8 –	6.7	7.7
MT	753	np	np	2.2	np	np	np	7.5
MT	812	4.3 +	5.8	2.4	6.8 +	7.5 +	7.0	8.3 +
MT	821	np	6.5 +	2.4	7.7 +	8.8 + +	7.9 +	8.1
MT	822	4.5 +	7.6 + +	2.5	7.2 +	8.2 +	8.8 + +	9.0 +
MT	811	4.3 +	6.7 +	3.0 + +	8.5 + +	6.6	6.9	7.9
MT	823	2.8 –	5.9	2.6 +	6.4	7.2	7.3 +	8.4 +
MT	824	5.3 + +	5.7	2.6 +	6.6 +	8.4 +	6.7	8.3 +
MT	825	4.8 +	6.6 +	2.8 +	7.5 +	6.7	7.6 +	8.9 +
MT	727	3.9	6.7 +	2.8 +	5.2 –	7.7 +	8.6 +	8.3 +
MT	826	np	7.1 +	2.2	7.9 + +	8.5 +	8.3 +	8.7 +
MT	827	4.1	5.4	2.4	6.1	7.2	7.5 +	8.3 +
MT	828	np	6.2 +	2.4	6.4	6.0 –	7.2	8.4 +
ND	701	4.6 +	5.4	2.1	5.1 –	5.9 –	6.9	8.7 +
SD	703	4.2	6.6 +	2.6 +	5.6	8.5 +	7.1	7.8
SD	704	4.1	5.8	2.4	6.1	7.8 +	6.3	8.0
WY	833	5.0 + +	6.2 +	2.2	6.2	7.2	7.2	7.5
SD	837	4.7 +	5.9	2.3	7.2 +	9.0 + +	6.7	8.7 +
SD	840	5.2 + +	5.6	1.9 –	5.5	5.9 –	7.4 +	8.6 +
NE	722	3.6	5.8	2.7 +	5.1 –	7.1	6.3	8.5 +
NE	852	3.9	5.2	2.1	5.3 –	6.9	6.7	7.5
NE	853	3.7	4.6 –	2.4	6.3	7.8 +	7.2	8.7 +
SD	854	3.5	5.2	1.9 –	5.8	5.4 –	5.8 –	8.6 +
NE	855	4.3 +	5.0	2.4	6.2	6.2	7.5 +	9.2 +

Table 3A.—Average tree heights (in feet) for each seed provenance in Northern plantations, and symbols to show percentage-of-plantation mean classes[1]—Continued

Seed Provenance Location & No.		Drumheller ALB	Indianhead SASK	Towner ND	Grand Rapids MN	Morris MN	Lamberton MN	Watertown SD
Northcentral Nebraska								
SD	757	4.5 +	7.5 + +	3.2 + +	6.8 +	7.4	7.9 +	9.5 +
NE	721	3.7	7.8 + +	3.4 + +	6.7 +	8.8 + +	8.3 +	9.9 + +
NE	720	4.8 +	7.6 + +	3.2 + +	5.9	8.8 + +	8.1 +	9.4 +
Central Rocky Mountains								
WY	830	2.9 –	4.7 –	2.1	4.6 –	6.5	5.5 –	6.0 –
WY	831	4.6 +	4.6 –	1.8 –	5.7	5.0 –	5.4 –	6.2 –
WY	848	3.8	4.4 –	1.5 --	5.4	5.4 –	5.6 –	6.5 –
WY	847	4.4 +	np	2.3	5.2 –	4.8 –	5.5 –	5.4 –
WY	857	3.1 –	4.2 –	1.2 --	5.3 –	5.6 –	5.9	5.9 –
NE	844	3.0 –	np	1.6 –	5.0 –	4.1 --	6.3	5.7 –
CO	760	3.1 –	4.2 –	1.7 –	4.9 –	4.8 –	5.7 –	5.5 –
CO	761	3.9	2.9 --	2.2	5.4	6.0 –	5.5 –	5.7 –
CO	762	3.0 –	4.2 –	1.9 –	3.9 --	6.5	5.4 –	5.8 –
CO	763	3.8	4.4 –	2.6 +	6.1	5.8 –	6.1	7.5
Foothills-Black Hills								
MT	813	4.4 +	6.0	2.3	7.2 +	6.4	7.3 +	6.7
MT	815	4.5 +	5.7	2.6+	6.9 +	6.8	5.7 –	8.0
MT	814	3.6	6.0	2.5	6.4	6.2	6.7	7.1
ND	702	4.7 +	4.5 –	2.2	5.4	7.0	5.8 –	7.8
WY	829	4.1	5.0	2.1	6.1	6.7	4.8 –	6.4 –
WY	832	3.9	4.3 –	1.9 –	5.9	6.2	6.4	7.4
WY	834	5.2 + +	5.7	2.4	7.0 +	6.1	6.8	8.4 +
WY	835	3.7	5.4	2.0 –	5.6	5.7 –	6.4	8.1
WY	836	3.9	5.0	2.1	6.3	6.1	7.0	8.4 +
SD	838	4.3 +	4.5 –	2.3	5.7	6.3	6.5	8.1
SD	839	3.7	5.2	1.9 –	6.4	7.9 +	6.7	8.1
WY	849	2.2 --	5.1	1.7 –	4.7 –	5.9 –	6.1	6.6 –
WY	850	3.2 –	4.7 –	1.9 –	5.5	5.5 –	5.3 –	6.2 –
NE	851	3.2 –	4.9 –	1.9 –	5.4	5.9 –	7.2	7.1
WY	846	4.0	6.0	1.5 --	5.5	7.4	8.2 +	6.3 –
NE	723	3.0 –	4.7 –	2.5	5.0 –	7.3	6.7	7.3
NE	845	3.9	np	1.9 –	5.4	5.7 –	4.0 --	6.7
NE	759	2.5 --	4.4 –	2.0 –	7.7 +	7.2	7.2	7.6
NE	758	2.9 –	4.2 –	2.1	5.3 –	6.5	5.8 –	7.6
NE	856	3.2 –	3.9 –	2.5	6.0	6.7	5.1 –	8.1
CO	858	2.1 --	4.0 –	1.7 –	5.2 –	5.3 –	5.6 –	5.2 –
CO	859	2.3 --	4.2 –	1.4 --	6.1	5.9 –	4.6 –	6.1 –
CO	724	2.9 –	3.9 –	1.8 –	4.7 –	5.0 –	5.7 –	6.9
CO	860	2.8 –	3.5 --	1.1 --	5.7	4.6 --	6.6	5.6 –
CO	861	2.5 --	4.0 –	1.5 --	4.5 –	5.9 –	4.4 --	4.8 --
CO	764	4.3 +	3.4 --	1.6 –	5.2 –	5.0 –	5.1 –	5.4 –
CO	765	2.4 --	np	1.1 --	0 --	6.6	6.5	5.0 --
NM	862	2.1 --	3.4 --	0 --	0 --	np	np	4.0 --
NM	863	np	4.3 –	0 --	0 --	0 --	4.2 --	2.0 --
Southern								
NM	864	np	0 --	0 --	0 --	0 --	5.6 –	np
NM	766	np	0 --	0 --	0 --	0 --	3.0 --	2.9 --
NM	767	np	0 --	0 --	np	0 --	4.8 –	0 --
NM	768	np	0 --	0 --	np	0 --	4.4 --	2.5 --
AZ	869	np	0 --	0 --	np	0 --	5.6 –	np
Plantation mean height		3.81	5.57	2.28	5.97	6.72	6.59	7.40
Total sources		63	70	79	70	72	72	73

[1]*Explanation: np = none planted; 0 = planted, zero survived.*
Symbols for percentage-of-plantation mean classes:
+ + greater than 130%
+ 111% to 130%
mean) 90% to 110%
– 70% to 89%
-- less than 70%

Table 3B.—Average tree heights (in feet) for each seed provenance in Central plantations, and symbols to show percentage-of-plantation mean classes[1]

Seed Provenance Location & No.		Alliance NE	Halsey NE	Hastings NE	Plattsmouth NE	Milford KS
Northwest						
OR	865	5.0 –	3.9	7.8	np	np
WA	866	4.6 --	2.7 --	7.2 –	np	3.8
ID	867	4.2 --	2.8 --	8.7	np	2.8 – –
MT	817	4.1 --	3.0 –	7.3 –	np	4.0
MT	818	4.9 –	3.2 –	6.9 –	np	2.7 – –
MT	819	4.3 --	3.9	8.2	13.5	3.0 –
MT	820	4.1 --	3.1 –	7.9	12.5	3.5 –
Northern High Plains						
MT	816	6.4	5.2 +	9.5 +	13.8	4.7 +
MT	754	6.5	4.9 +	9.0	np	5.2 +
MT	753	5.0 –	4.2	8.3	np	np
MT	812	7.4	4.1	8.6	np	4.6
MT	821	6.5	4.1	9.4	np	4.5
MT	822	7.4	4.8 +	10.3 +	15.2 +	4.9 +
MT	811	7.3	4.5	10.2 +	14.3 +	4.7 +
MT	823	6.8	5.1 +	9.3	np	4.9 +
MT	824	7.0	4.6 +	9.2	14.1	4.4
MT	825	7.9 +	4.8 +	10.0 +	np	5.1 +
MT	727	7.2	4.3	8.1	np	3.6 –
MT	826	6.3	3.8	8.5	13.5	4.0
MT	827	7.1	4.7 +	9.4	13.9	4.7 +
MT	828	7.7 +	4.8 +	8.4	np	4.7 +
ND	701	7.5 +	4.0	8.9	np	4.0
SD	703	7.1	4.4	9.2	np	4.1
SD	704	6.7	4.2	8.8	13.1	4.4
WY	833	7.1	4.2	9.8 +	13.4	4.1
SD	837	7.3	4.3	9.7 +	12.6	4.4
SD	840	7.0	5.2 +	9.1	13.6	4.4
NE	722	7.1	5.0 +	8.8	np	4.6
NE	852	7.2	4.7 +	9.9 +	13.3	4.6
NE	853	7.0	5.1 +	8.9	13.9	5.1 +
SD	854	6.7	4.3	9.1	13.6	4.7 +
NE	855	7.9 +	5.0 +	9.3	np	5.1 +
Northcentral Nebraska						
SD	757	7.9 +	5.8 + +	11.0 +	np	6.4 + +
NE	721	7.8 +	4.3	11.0 +	14.8 +	6.9 + +
NE	720	7.4	5.6 + +	11.8 + +	14.9 +	8.1 + +
Central Rocky Mountains						
WY	830	6.0 –	3.2 –	7.2 –	np	3.4 –
WY	831	6.0 –	3.5 –	7.5 –	11.2 –	4.2
WY	848	5.7 –	3.1 –	7.3 –	11.1 –	3.0 –
WY	847	6.9	2.8 --	8.0	np	3.1 –
WY	857	5.9 –	2.6 --	7.1 –	10.3 –	3.6 –
NE	844	6.5	3.0 –	7.1 –	np	3.2 –
CO	760	5.3 –	3.2 –	6.6 –	9.5 –	3.1 –
CO	761	6.6	3.3 –	7.1 –	np	3.2 –
CO	762	6.2	4.5	7.2 –	12.3	3.2 –
CO	763	7.0	3.6 –	7.4 –	11.5	3.6 –

Table 3B.—Average tree heights (in feet) for each seed provenance in Central plantations, and symbols to show percentage-of-plantation mean classes[1]—Continued

Seed Provenance Location & No.		Alliance NE	Halsey NE	Hastings NE	Plattsmouth NE	Milford KS
Foothills-Black Hills						
MT	813	6.7	3.3 –	8.0	11.6	4.0
MT	815	7.4	3.8	8.3	13.1	3.4 –
MT	814	6.8	3.6 –	8.9	np	4.0
ND	702	6.7	4.1	8.5	13.0	3.8
WY	829	6.2	3.5 –	8.3	12.0	4.3
WY	832	6.8	4.3	9.5 +	13.6	4.8 +
WY	834	8.4 +	3.7	8.2	12.1	4.0
WY	835	7.5 +	3.8	9.0	12.9	4.0
WY	836	7.7 +	4.1	8.6	np	3.5 –
SD	838	7.1	4.4	7.7	12.1	4.0
SD	839	7.2	4.4	8.6	np	3.8
WY	849	6.5	3.1 –	8.8	12.8	3.7 –
WY	850	7.2	4.1	7.7	np	4.3
NE	851	6.7	3.8	8.4	13.0	4.1
WY	846	7.3	4.1	8.0	12.6	4.8 +
NE	723	6.5	4.4	9.0	13.0	4.5
NE	845	5.8 –	4.0	8.4	11.7	3.4 –
NE	759	7.3	4.5	9.1	np	4.3
NE	758	7.0	4.7 +	7.7	12.9	3.7 –
NE	856	7.0	4.3	8.4	12.6	5.0 +
CO	858	5.9 –	2.9 –	8.1	np	3.7 –
CO	859	6.9	4.2	8.1	11.7	3.2 –
CO	724	6.4	3.8	8.1	np	3.9
CO	860	6.2	3.8	7.4 –	11.3 –	3.5 –
CO	861	5.4 –	3.2 –	7.8	12.1	3.8
CO	764	6.6	3.9	9.3	12.6	4.4
CO	765	6.8	3.9	8.6	13.7	4.7 +
NM	862	6.3	4.2	7.3 –	11.7	3.9
NM	863	6.2	3.6 –	8.5	13.3	3.5 –
Southern						
NM	864	5.5 –	2.6 --	7.2 –	12.3	3.9
NM	766	6.5	0 --	8.2	13.0	2.9 --
NM	767	6.4	0 --	8.1	13.3	3.2 –
NM	768	6.9	0 --	7.7	13.6	3.8
AZ	869	6.0 –	0 --	7.8	13.3	3.7 –
Plantation mean height		6.71	4.12	8.56	12.83	4.18
Total sources		79	79	79	50	77

[1]*Explanation: np = none planted; 0 = planted, zero survived.*
Symbols for percentage-of-plantation mean classes:

+ + *greater than 130%*
+ *111% to 130%*
(mean) 90% to 110%
– *70% to 89%*
-- *less than 70%*

Table 3C.—Average tree heights (in feet) for each seed provenance in Southern and Eastern plantations, and symbols to show percentage-of-plantation mean classes[1]

Seed Provenance Location & No.		Norman OK	Mt. Vernon MO	Columbia MO	Kellog MI	Philipsburg PA
Northwest						
OR	865	np	8.0	9.4	13.0	np
WA	866	6.8	7.8	10.8 +	13.6 +	np
ID	867	np	8.5	10.1	13.7 +	np
MT	817	np	7.6 –	9.2	11.9	np
MT	818	np	8.7	10.5 +	13.2 +	np
MT	819	np	8.3	9.8	13.2 +	np
MT	820	7.4	8.6	10.0	13.3 +	np
Northern High Plains						
MT	816	6.8	8.0	10.6 +	13.9 +	np
MT	754	6.8	7.6 –	9.6	12.3	4.5 –
MT	753	np	np	np	np	np
MT	812	np	9.0	10.2	12.8	5.6
MT	821	7.4	9.1	9.6	11.8	np
MT	822	np	9.8 +	11.6 +	13.4 +	5.6
MT	811	8.0 +	9.0	10.2	13.4 +	np
MT	823	np	9.4	10.3	12.5	6.4 +
MT	824	np	9.6 +	9.9	13.5 +	6.4 +
MT	825	8.2 +	9.1	11.1 +	13.4 +	6.8 +
MT	727	np	8.5	8.6	11.1	np
MT	826	6.5	8.6	9.1	11.8	np
MT	827	np	9.3	10.6 +	12.1	5.6
MT	828	np	9.1	10.1	13.4 +	np
ND	701	np	9.1	9.8	11.9	6.2 +
SD	703	np	7.8	9.0	12.3	5.1
SD	704	7.1	9.0	9.6	11.7	6.5 +
WY	833	np	8.6	10.0	12.4	5.0
SD	837	6.7	8.7	10.1	np	5.2
SD	840	6.6	9.1	9.8	11.3	np
NE	722	7.7	9.0	9.7	11.9	4.5 –
NE	852	7.0	9.4	10.0	12.0	5.2
NE	853	np	9.7 +	10.1	12.0	6.5 +
SD	854	np	9.6 +	10.9 +	np	5.5
NE	855	8.9 +	9.4	9.5	11.6	np
Northcentral Nebraska						
SD	757	np	10.1 +	10.2	13.7 +	7.8 + +
NE	721	10.2 + +	11.0 +	10.2	np	np
NE	720	10.7 + +	11.0 +	10.9 +	13.8 +	6.8 +
Central Rocky Mountains						
WY	830	5.5 –	6.3 –	7.6 –	9.0 –	4.7 –
WY	831	np	6.8 –	7.6 –	10.7	4.6 –
WY	848	np	6.8 –	7.4 –	9.7 –	4.8 –
WY	847	np	7.5 –	8.3 –	10.2 –	4.5 –
WY	857	5.4 –	6.1 –	6.8 –	9.6 –	np
NE	844	np	7.4 –	7.2 –	10.6	np
CO	760	4.9 --	5.8 --	6.5 --	9.5 –	4.7 –
CO	761	np	6.5 –	7.2 –	9.9 –	4.9
CO	762	5.9 –	8.3	8.2 –	9.6 –	np
CO	763	np	7.1 –	7.4 –	11.2	4.4 –

Table 3C.—Average tree heights (in feet) for each seed provenance in Southern and Eastern plantations, and symbols to show percentage-of-plantation mean classes[1]—Continued

Seed Provenance Location & No.		Norman OK	Mt. Vernon MO	Columbia MO	Kellog MI	Philipsburg PA
Foothills-Black Hills						
MT	813	np	7.1 –	8.2 –	12.4	4.7 –
MT	815	np	7.6 –	10.1	11.1	5.5
MT	814	np	8.2	8.5	11.4	5.7
ND	702	6.5	8.2	9.2	12.8	4.9
WY	829	np	7.5 –	9.2	10.3 –	4.8 –
WY	832	6.4	9.3	9.6	11.8	5.7
WY	834	np	8.2	8.4	12.4	5.7
WY	835	6.0 –	8.7	9.4	12.5	5.9
WY	836	np	8.5	8.4	11.0	5.7
SD	838	np	7.8	8.8	11.3	4.2 –
SD	839	np	8.2	8.4	12.0	5.4
WY	849	6.0 –	7.8	8.6	10.9	np
WY	850	np	8.4	10.3	12.0	np
NE	851	np	8.5	10.1	12.3	5.6
WY	846	np	8.6	8.5	12.2	np
NE	723	6.8	9.0	9.2	12.0	5.3
NE	845	np	7.7 –	7.8 –	12.1	4.9
NE	759	np	8.9	9.1	12.2	4.9
NE	758	6.9	8.6	9.2	11.3	4.9
NE	856	9.7 + +	9.4	9.6	10.4 –	5.3
CO	858	5.5 –	8.9	8.2 –	12.0	5.2
CO	859	np	9.1	8.5	11.2	np
CO	724	6.2 –	9.0	8.4	11.5	5.8
CO	860	6.8	8.8	9.0	10.4 –	5.0
CO	861	6.5	8.9	8.4	11.5	4.6 –
CO	764	6.4	7.6 –	9.1	11.3	np
CO	765	6.9	9.8 +	10.4 +	11.5	6.2 +
NM	862	6.3 –	9.0	10.1	10.7	6.0 +
NM	863	7.6	10.3 +	9.6	11.4	6.5 +
Southern						
NM	864	7.7	9.7 +	9.8	11.7	np
NM	766	6.8	10.2 +	9.7	12.2	np
NM	767	7.5	10.3 +	10.7 +	10.6	np
NM	768	9.4 + +	11.5 + +	10.2	11.8	np
AZ	869	6.9	9.9 +	10.7 +	13.0	np
Plantation mean height		7.13	8.61	9.37	11.82	5.41
Total sources		40	78	78	75	49

[1] *Explanation: np = none planted; 0 = planted, zero survived.*
Symbols for percentage-of-plantation mean classes:
+ + *greater than 130%*
\+ *111% to 130%*
(mean) 90% to 110%
– *70% to 89%*
-- *less than 70%*

Table 4.—Distribution of percentage-of-plantation mean classes, by seed provenance; and indication of best overall provenances

Provenance No.	Location		Number of Plantations by Percentage-of-Plantation Mean Classes					Best overall performance[1]
			<70%	70-89%	90-110%	111-130%	>130%	
Northwest								
865	Bend	OR	2	3	5			
866	Okanogan	WA	3	3	6	2		
867	Golden Valley	ID	8		3	1		
817	Missoula	MT	1	3	4			
818	Lolo	MT	1	4	1	2		
819	Darby	MT	2	2	5	1		
820	Hamilton	MT	1	3	5	1		
Northern High Plains								
816	Helena	MT			6	10		*
754	Monarch	MT		4	9	3		
753	Windham	MT		1	4			
812	Winifred	MT			11	4		
821	Columbus	MT			10	3	1	
822	Roundup	MT			3	11	2	**
811	Jordan	MT			7	7	2	*
823	Bighorn	MT		1	8	6		
824	Colstrip	MT			7	8	1	*
825	Ashland	MT			2	14		**
727	Fallon	MT		2	7	5		
826	Glendive	MT			10	4	1	
827	Ekalaka	MT			11	5		
828	Camp Crook	MT		1	6	6		
701	Amidon	ND		2	9	4		
703	Ludlow	SD			12	3		
704	Reva	SD			15	2		
833	Aladdin	WY			13	2	1	
837	Lead	SD			11	4	1	
840	Hermosa	SD		2	10	3	1	
722	Chadron	NE		2	11	3		
852	Rushville	NE		1	14	2		
853	Whiteclay	NE		1	9	6		
854	Martin	SD		3	8	4		
855	Merriman	NE			8	7		
Northcentral Nebraska								
757	Rosebud	SD			2	8	5	***
721	Valentine	NE			3	6	6	***
720	Ainsworth	NE			2	8	7	***
Central Rocky Mountains								
830	Sheridan	WY		14	2			
831	Buffalo	WY		12	3	1		
848	Douglas	WY	1	13	2			
847	Wheatland	WY	1	9	3	1		
857	Buford	WY	2	13	1			
844	Pine Bluff	NE	1	9	3			
760	Allenspark	CO	3	14				
761	Boulder	CO	1	9	5			
762	Limon	CO	1	10	5			
763	Woodland Park	CO		8	7	1		

Table 4.—Distribution of percentage-of-plantation mean classes, by seed provenance; and indication of best overall provenances—Continued

Provenance No.	Location		Number of Plantations by Percentage-of-Plantation Mean Classes					Best overall performance[1]
			<70%	70-89%	90-110%	111-130%	>130%	
Foothills-Black Hills								
813	Zortman	MT		4	9	3		
815	Lewistown	MT		3	10	3		
814	Grassrange	MT		1	14			
702	Medora	ND		2	14	1		
829	Dayton	WY		6	10			
832	Recluse	WY		2	13	2		
834	Sundance	WY			12	3	1	
835	Newcastle	WY		3	13	1		
836	Clifton	WY		1	12	2		
838	Hill City	SD		2	13	1		
839	Nemo	SD		1	13	1		
849	Shawnee	WY	1	7	8			
850	Lusk	WY		6	8			
851	Ft. Robinson	NE		4	12			
846	Ft. Laramie	WY	1	1	11			
723	Scottsbluff	NE		3	14			
845	Harrisburg	NE	1	6	8			
759	Dalton	NE	1	2	11	1		
758	Potter	NE		5	11	1		
856	Arnold	NE		4	11	1	1	
858	Ft. Collins	CO	1	11	4			
859	Franktown	CO	2	5	8			
724	Eastonville	CO		7	9			
860	Colo. Springs	CO	3	6	8			
861	Rye	CO	4	6	7			
764	Gardner	CO	1	6	8	1		
765	Gulnare	CO	4		8	4		
862	Raton	NM	5	2	7	1		
863	Ft. Union	NM	5	3	6	2		
Southern								
864	Las Vegas	NM	5	3	5	1		
766	Ruidoso	NM	8		6	1		
767	Mayhill	NM	5	2	5	2		
768	Guadalupe	NM	6		6		2	
869	Ft. Valley	AZ	4	3	4	2		

[1] *** *Best*
** *Good*
* *Acceptable*

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APPENDIX

THE 17 FIELD PLANTATIONS USED IN THIS STUDY,
AND NAMES AND AFFILIATIONS OF COOPERATORS

Plantation Location	Cooperators	Agency
Drumheller, Alberta	Klem Froning	Canadian Forestry Service, Winnipeg
Indianhead, Saskatchewan	J.W. Hamm, Rudy Esau, Gordon Howe	Canada Department Regional Economic Expansion, Indianhead
Towner, N. Dak.	Paul Slabaugh, R.A. Cunningham, James Van Deusen	Rocky Mountain Forest and Range Experiment Station
Grand Rapids, Minn. Morris, Minn. Lamberton, Minn.	Scott S. Pauley Carl A. Mohn	College of Forestry, Univ. of Minnesota, St. Paul
Watertown, S. Dak.	D. Townsend	Big Sioux Nursery, So. Dakota Forestry Department, Watertown
	Paul E. Collins Norman Baer	Department of Horticulture & Forestry, South Dakota State Univ., Brookings
Alliance, Nebr. Halsey, Nebr. Hastings, Nebr.	Ralph A. Read	Rocky Mountain Forest and Range Experiment Station
Plattsmouth, Nebr.	Glenn W. Peterson	Rocky Mountain Forest & Range Experiment Station
Milford, Kan.	Fred Deneke Keith Lynch	Department of Horticulture & Forestry, Kansas State University, Manhattan
Norman, Okla.	Clayton Posey Charles Tauer Robert Gardner	Dept. Forestry, Oklahoma State University, Stillwater and Oklahoma Division of Forestry
Mt. Vernon, Mo. Columbia, Mo.	R. Brooks Polk Henry Stelzer	School of Forestry, Univ. of Missouri, Columbia Missouri Department of Conservation
Kellog, Mich.	Jonathan W. Wright	Dept. of Forestry, Michigan State University, East Lansing
Philipsburg, Pa.	Walter H. Davidson	Northeastern Forest Experiment Station, Kingston

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Read, Ralph A. 1983. Ten-year performance of ponderosa pine provenances in the Great Plains of North America. USDA Forest Service Research Paper RM-250, 17 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

A cluster and discriminant analysis based on nine of the best plantations, partitioned the seed provenance populations into six geographic clusters according to their consistency of performance in the plantations.

The Northcentral Nebraska cluster of three provenances performed consistently well above the average in all plantations. These easternmost stands of ponderosa pine along the Niobrara River escarpment in Nebraska from about 101° longitude and eastward, and those in the drainage of the South Fork of the White River near Rosebud, S. Dak. are recommended for tree planting in all Great Plains states.

Keywords: *Pinus ponderosa*, survival, height growth, provenances

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Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

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